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REACTIVE-ION ETCHING METHOD

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[There are no amendments to this patent.]

Claims

1. A reactive-ion etching method characterized by the fact that an Al film or an alloy film which uses Al as the principal component deposited on a silicon wafer is etched with a mixed gas of BCl_3, Cl_2, and He within a vacuum chamber.

2. A reactive-ion etching method of Claim 1 characterized by the fact that the operation pressure during the etching is 80-180 Pa.

3. A reactive-ion etching method of Claim 1 or 2 characterized by the fact that the gas flow rate ratio of BCl_3 and Cl_2 is 30-60% for the reaction $Cl_2/(BCl_3 + Cl_2)$.

4. A reactive-ion etching method of Claims 1-3 characterized by the fact that each wafer is etched in an individual processing system.

Detailed explanation of the invention

Technical field of the invention

The present invention relates to a reactive-ion etching method. In particular, it relates to a reactive-ion etching method which etches the Al film or alloy film of Al, Si, and Cu on a wafer.

Technical background of the invention and the problems

Al or an alloy thereof is used as a wiring material for integrated circuits. In order to form a wiring of Al, etc., the method of selectively etching an Al film, etc. by depositing an Al film or an Al alloy film by the vapor deposition method, sputtering method, or CVD method on a wafer, forming a resist pattern on said Al film by the photographic etching method, and using said resist pattern as a mask is used. In this etching method, the conventional wet etching method which uses an etching solution is used. However, in this method, the etching progresses isotopically so formation of fine wiring pattern of below 3 μm was not possible.

Consequently, reactive-ion etching in which anisotropic etching is possible has begun to be used in recent years. In this method a wafer with Al film, etc. deposited is installed in a reactive gas plasma and ions accelerated by direct current field are vertically input onto the surface of the wafer so anisotropic etching becomes possible.

In order to counter the automization of the process and enlarge the aperture in the wafer, individual processing system devices have has become the mainstream. In the individual processing system, high speed etching is necessary in order to compete with the batch processing system with throughput. Moreover, the characteristics such as processing shape, etching selection ratio, etc. require high speed etching equal to the batch processing system. Many methods are being examined for said reactive-ion etching to satisfy said requirements. For example, the method which uses an etching gas of BCl_3, Cl_2, CCl_4, $SiCl_4$,

etc., the cathodic coupling method which applies high frequency to the electrode for loading the wafer, the method which improves the high frequency application in the anodic coupling method which loads the wafer on a counter electrode, etc. have been proposed. However, it was difficult to achieve high speed etching and satisfy the etching selectivity ratio and processing shape in said methods. There are many causes for this but there are the following three main factors.

1. Al surface has a tendency to be oxidized and is covered with a hard Al_2O_3 film so long time is needed to etch this and the etching speed drops as a whole.

2. Al is etched chemically (etching progresses even outside a plasma atmosphere) so when etching is accelerated too much there is a tendency towards an isotropic etching shape.

3. When the etching speed of Al is enhanced, degradation of the resist is caused due to the reaction heat.

Objective of the invention

The present invention aims to provide a reactive-ion etching method which can prevent degradation of the resist and in which high speed anisotropic etching is possible in reactive ion etching of Al film or Al alloy film on a wafer.

Summary of the invention

The present inventors found a reaction ion etching method which can prevent degradation of the resist and in which high speed anisotropic etching is possible for reactive-ion etching Al film or Al alloy film on a wafer as noted above by using BCl_3 which functions effectively in removing the Al_2O_3 film formed on the surface of Al film, etc., using Cl_2 for increasing the etching speed, and using He which has cooling effect.

Namely, said invention is characterized by the fact that etching of Al film or alloy film in which Al is the principal component deposited on a silicon wafer is executed with a mixed gas of BCl_3, Cl_2, and He within a vacuum chamber.

Examples of said alloy film in which Al is the principal component include, for example, Al-Si alloy film, Al-Cu alloy film, Al-Si-Cu alloy film, etc.

It is preferable for the operation pressure during the etching within in said chamber to be in the range of 80-180 Pa from the point of view of manifesting etching speed at which problem is not created for practical use in the individual processing system and for securing anisotropic shape at the same time.

It is preferable for the gas flow rate ratio of BCl_3 and Cl_2 of which the mixed gas is composed be in the range of 30-60% for the ratio $Cl_2/(BCl_3 + Cl_2)$ from the point of view of manifesting etching speed at which problem is not created for practical use in the individual processing system and for securing anisotropic shape at the same time.

It is preferable for the feed quantity of He composing said mixed gas to be over 500 SCCM from the point of view of achieving

sufficient cooling effect during the etching. As the feeding top limit for He, it is preferable to be 2000 SCCM from the point of view of exhaust performance, etc.

Application example

Below, an application example of the present invention will be explained in detail by referring to Figure 1.

Figure 1 is a sectional figure of a cathodic reactive-ion etching device used in the application example of the present invention. In the figure, (1) is the vacuum chamber. A pair of opposing parallel electrodes (2) and (3) are arranged within said chamber (1). The upper electrode (2) has a box shape, a gas spray port (not shown in the figure) is cut into the surface opposing said lower electrode (3), and said electrode (2) is connected to gas introduction pipe (4). A mixed gas of BCl_3, Cl_2, and He is fed as reaction gas into said gas introduction pipe (4). The flow rate of these gases are made to be set freely controlled by mass flow. Also, said upper electrode (2) is connected to the ground. Cold water circulation piping (5) for cooling said electrode (3) is connected to said lower electrode (3). Also, said lower electrode (3) is connected to the ground via high frequency power source (7) and matching network (6). When high frequency is input between said pair of electrodes (2) and (3) from high frequency power source (7), a self bias voltage (V_{dc}) is generated at the vicinity of lower electrode (3) from the difference in mobility of the ions and electrons, and thereby, the accelerated ions strike the wafer on the lower electrode. Exhaust pipe (8) is connected to the bottom part of said vacuum chamber (1). A rotary pump and mechanical booster pump not shown in the figure are

connected to said exhaust pipe (8). Also, heater (9) is provided at the outer circumference of said chamber (1).

Next, the etching method of said invention will be explained by using said reactive-ion etching device.

First of all, oxide film (12) with thickness of about 1000 Å is formed by thermal oxidation on semiconductor substrate (silicon wafer) (11) 5 inches in diameter composed of monocrystalline silicon, processing, and after depositing Al-Si film (13) with thickness of about 8000 Å on said oxide film (12) by the sputtering method, resist pattern (14) is formed on said Al-Si film (13) by the photoetching method (shown in Figure 2). Next, said wafer (11) is placed on lower electrode (3) within vacuum chamber (1) shown in Figure 1. Then, a vacuum is created within (1) at 1×10^{-3} torr with a rotary pump and mechanical booster pump not shown in the figure and the residual gas from exhaust pipe (8) is thoroughly exhausted. Next, BCl_3, Cl_2, and He gases as the reaction gas are fed into chamber (1) from gas introduction pipe (4) by controlling the flow rate through the mass flow control, the pressure is controlled with the conduction valve located between chamber (1) and mechanical booster, then, high frequency power of 300 W is applied to lower electrode (3) from high frequency power source (7) (13.56 MHz) to generate plasma between electrodes (2) and (3), and the accelerated ions

impact onto Al-Si film (13) exposed from resist pattern (14) of wafer (11) to execute etching of Al-Si film (13).

Along with feeding 1400 SCCM of He and feeding 70 SCCM of both BCl_3 and Cl_2, when the relationship of the processed shape of the Al-Si film and the etching speed of the Al-Si film were checked with ratio of BCl_3/Cl_2 as the parameter, the characteristic graph shown in Figure 3 was obtained. For the etching speed of the Al-Si film, the step formed by etching on the Al-Si film surface by peeling off resist pattern (14) with a parallel asher [transliteration] device after the reactive-ion etching was measured with a tari [transliteration] step device. Also, in the observation of the processed shape of the Al-Si film, the anisotropy was judged by pulverizing wafer (11) after the reactive-ion etching of Al-Si film and observing the cross section with a scanning type electron microscope. The area on the right side of the slanted line in Figure 3 is the area where undercut is generated. As apparent from Figure 3, when the feeding amount of Cl_2 is increased, namely, the BCl_3/Cl_2 ratio is reduced in the reactive-ion etching with mixed gas of $BCl_3/Cl_2/He$, the etching speed of Al-Si film increases, but the processed shape takes on a state in which an undercut is generated. On the other hand, when the feeding amount of Cl_2 is reduced and the amount of BCl_3 is increased, the processed shape becomes anisotropic. From the above, it is apparent that the flow rate ratio condition for BCl_3 and Cl_2 which manifests an etching speed at which problems for practical use are not created in the individual processing system and which can secure anisotropic shape at the same time is in the range of 30-60% for $Cl_2/(BCl_3 + Cl_2)$.

When the pressure dependence (pressure within the chamber) of the etching speed for $Cl_2/(BCl_3 + Cl_2)$ set at 45% was checked, the characteristic graph shown in Figure 4 was obtained. As apparent from this Figure 4, the pressure condition which manifests etching speed at which problems for practical use are not created in the individual processing system and an anisotropic shape can be secured at the same time is 80-180 Pa.

In said application example, explanation was given using a cathodic coupling reactive-ion etching device but the same effects can be achieved even when an anodic coupling reactive-ion etching device is used by controlling the ratio of BCl_3 and Cl_2 within said range.

Effects of the invention

As discussed in detail above, according to said invention, a reactive-ion etching method can be provided which has noticeable effects such as anisotropic etching being possible at high speed, the ability to prevent degradation of the resist, and the ability to form Al or Al alloy wiring of high precision with favorable efficiency, etc. in reactive-ion etching an Al film or Al alloy film on a wafer.

Brief description of the figures

Figure 1 is a cross section showing one mode of a cathodic coupling reactive-ion etching device used in the application example of said invention, Figure 2 is a cross section showing the shape of a wafer to which reactive-ion etching is applied in said application example, Figure 3 is a characteristic graph showing the relationship between the etching speed of Al-Si film and the ratio of C/2/(BCl_3 + Cl_2), and Figure 4 is a characteristic graph showing the relationship between the etching speed and the operation pressure within the vacuum chamber.

(1)...vacuum chamber, (2)...upper electrode, (3)...lower electrode, (4)...gas introduction pipe, (7)...high frequency power source, (8)...exhaust pipe, (11)...wafer, (13)...Al-Si film, (14)...resist pattern.

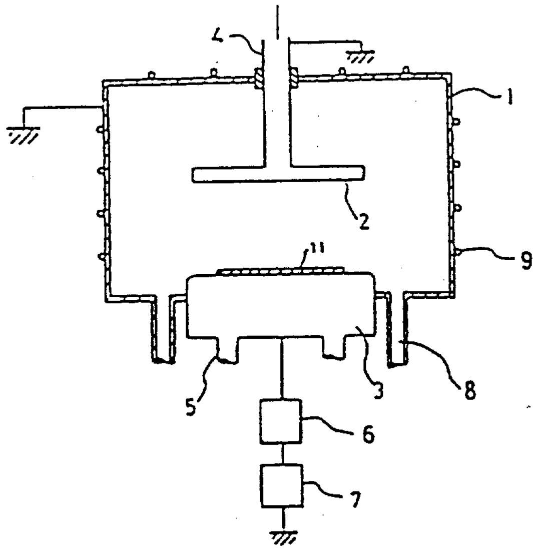

Figure 1

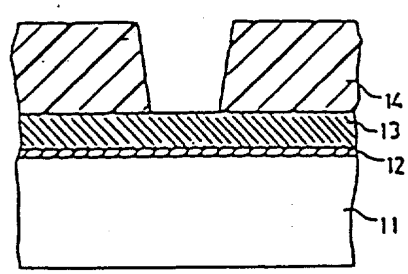

Figure 2

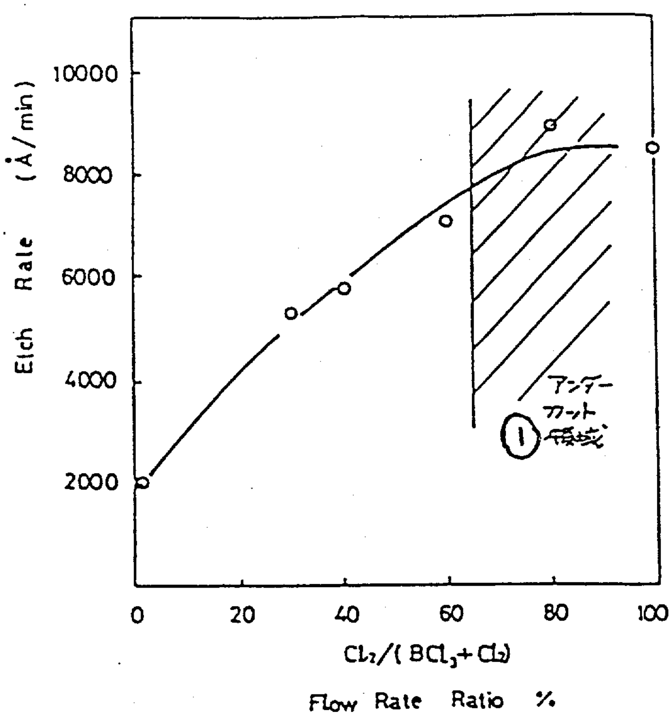

Figure 3

Key: 1 Undercut area

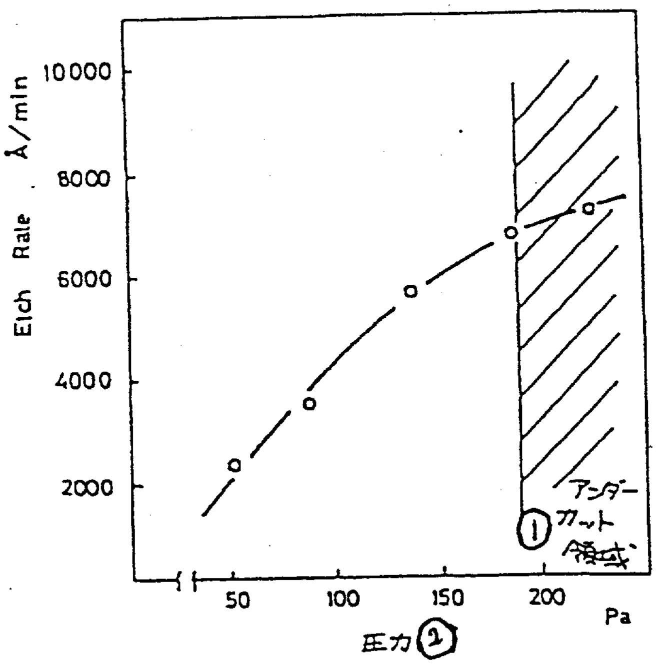

Figure 4

Key: 1 Undercut area
2 Pressure